1MHz, 2A High-Efficiency Synchronous-Rectified Buck Converter

General Description

The uP1746 is a high efficiency synchronous-rectified buck converter with internal power switches. Fixed 1MHz PWM operation allows possible smallest output ripple and external component size. With high conversion efficiency and small package, the uP1746 is ideally suitable for portable devices and USB/PCIE-based interface cards where PCB area is especially concerned. With internal low $R_{DS(ON)}$ switches, the uP1746 is capable of delivering 2A output current over a wide input voltage range from 2.6V to 5.5V. The output voltage is adjustable from 0.6V to V_{IN} by a voltage divider. Other features include internal soft-start, chip enable, under voltage, over temperature and over current protections. The uP1746 is available in space-saving TSOT23-5L, TSOT23-6L, WDFN2x2-6L and WQFN3x3-16L packages with adjustable version of output voltages.

Ordering Information

Order Number	Package	Top Marking
uP1746PMT5-00	TSOT23-5L	S90P
uP1746PMT6-00	TSOT23-6L	S87P
uP1746PDE6-00	WDFN2x2-6L	EQP
uP1746PQDD	WQFN3x3-16L	uP1746P

Note:
(1) Please check the sample/production availability with uPI representatives.
(2) uPI products are compatible with the current IPC/JEDEC J-STD-020 requirement. They are halogen-free, RoHS compliant and 100% matte tin (Sn) plating that are suitable for use in SnPb or Pb-free soldering processes.

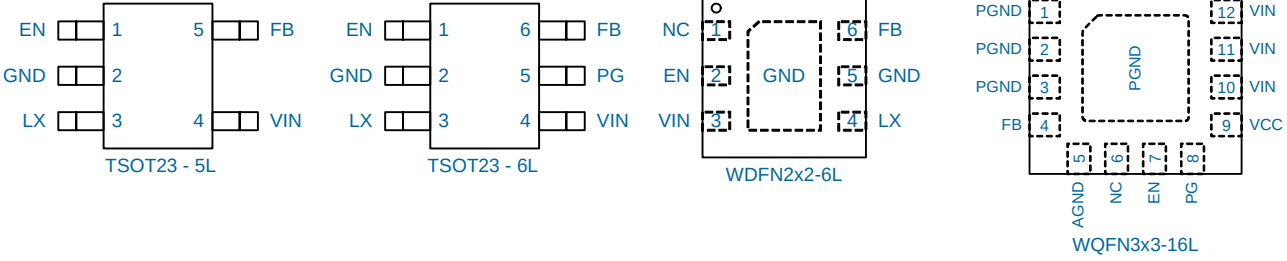
Features

- 2.6V to 5.5V Input Voltage Range
- 2A Guaranteed Output Current
- Accurate Reference 0.6V with ±1.5% Accuracy
- Up to 95% Conversion Efficiency
- Typical Quiescent Current: 40uA
- V_{OUT} Power OK Signal
- Integrated Low $R_{DS(ON)}$ Upper and Lower MOSFET Switches: 100mΩ and 80mΩ
- Current Mode PWM Operation
- Fixed Frequency: 1MHz
- 100% Maximum Duty Cycle for Lowest Dropout
- Under Voltage Protection
- Over Current and Over Temperature Protection
- RoHS Compliant and Halogen Free

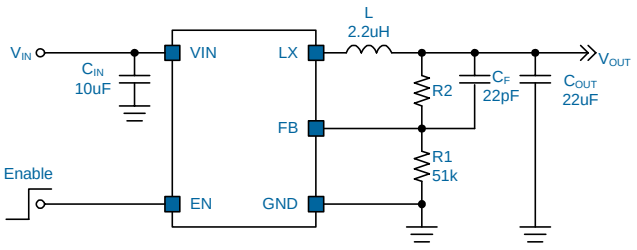
Applications

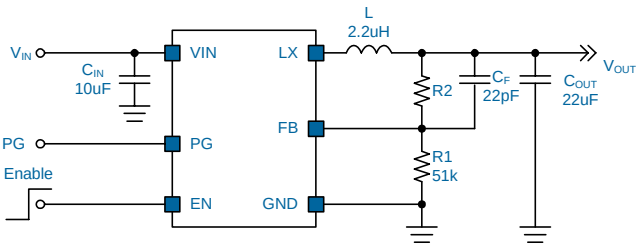
- Battery-Powered Portable Devices
  - MP3 Players
  - Digital Still Cameras
  - Wireless and DSL Modems
  - Personal Information Applications
  - Cellular Telephones
- 802.11 WLAN Power Supplies
- FPGA/ASIC Power Supplies
- Dynamically Adjustable Power Supply for CDMA/WC SMA Power Amplifiers
- USE-Based xDSL Modems and Other Network Interface Cards

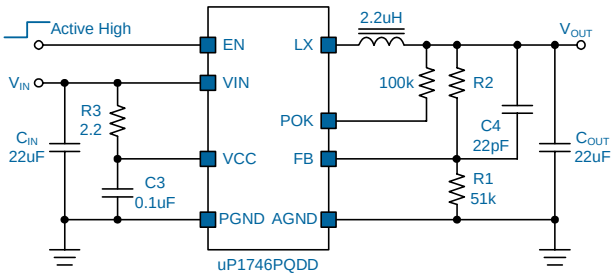
Pin Configuration



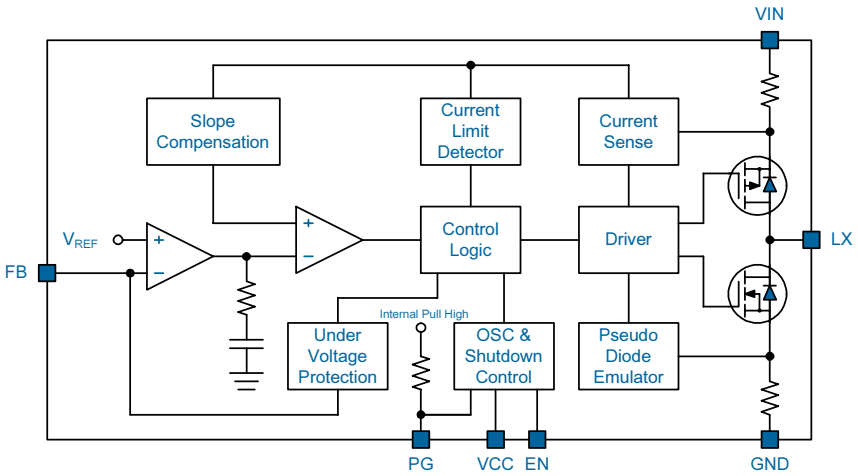
Typical Application Circuit







Functional Block Diagram



Functional Pin Description

Name	Pin Function
EN	**Chip Enable (Active High).** Logic low shuts down the converter.
GND (AGND,PGND)	**Ground.** Ground of the buck converter.
LX	**Internal Switches Output.** Connect this pin to the output inductor.
VIN	**Power Supply Input.** Input voltage that supplies current to the output voltage and powers the internal control circuit. Bypass input voltage with a minimum4.7uF X5R or X7R ceramic capacitor.
VCC	**Bias Supply.** Supply power to the internal circuitry. Connect to input power via low pass filter with decoupling to AGND. This pin is only available for uP1746PQDD.
PG	**Power OK Indication.** This pin is an internal pull high and is set high impedance once V_{OUT} reaches 90% of its rating voltage.
FB	**Feedback Voltage.** This pin is the inverting input to the error amplifier. A resistor divider from the output to GND is used to set the regulation voltage as V_{OUT} = 0.6(1+R2/R1) (V).
NC	**Not Internally Connected.**

Functional Description

The uP1746 is a high-efficiency synchronous-rectified buck converter with internal power switch. With internal low $R_{DS(ON)}$ switches, the high-efficiency buck converter is capable of delivering 2A output current over a input voltage range from 2.6V to 5.5V. The output voltage is adjustable down to 0.6V. Other features for the buck converter include 1MHz switching frequency, internal 1ms soft-start, under voltage protection, over current protection and over temperature protection. It is available in the TSOT23-5L, TSOT23-6L, WDFN2X2-6L and WQFN3x3-16L packages.

Input Supply Voltage, VIN

V_{IN} supplies current to internal control circuits and output voltages. The supply voltage range is from 2.6V to 5.5V. A power on reset (POR) continuously monitors the input supply voltage. The POR level is typically 2.5V at V_{IN} rising. The buck converter draws pulsed current with sharp edges each time the upper switch turns on, resulting in voltage ripples and spikes at supply input. A minimum 10uF ceramic capacitor with shortest PCB traces is highly recommended for bypassing the supply input.

Chip Enable/Disable and Soft Start

The uP1746 features an EN pin for enable/disable control of the output voltage. Pulling the EN pin lower than 0.4V shuts down the IC. In the shutdown mode, both upper and lower switches are turned off.

Pulling EN pin higher than 1.5V enables the IC and initiates the soft start. In soft start process, the output voltage is ramped to regulation voltage in typically 1ms. The 1ms soft start time is set internally.

Output Voltage Setting and Feedback Network

The output voltage can be set from V_{FB} to V_{IN} by a voltage divider as:

$$V_{OUT} = \frac{R1+R2}{R1} \times 0.6V$$

The V_{FB} is 0.6V with 1.5% accuracy. In real applications, a 22pF feed-forward ceramic capacitor is recommended in parallel with R2 for better transient response.

Current Limit Function

The uP1746 continuously monitors the inductor current for current limit by sensing the voltage drops across the upper switch when it turns on. When the inductor current is higher than current limit threshold 2.5A (Min), the current limit function activates and forces the upper switch turning off to limit inductor current cycle by cycle. If the load continuously demands more current than what uP1746 could provide, uP1746 cannot regulate the output voltage. Eventually under voltage protection will be triggered if V_{OUT} is too low.

Low Dropout Mode

The uP1746 increases duty cycle to maintain output voltage within its regulation as the supply input drops gradually in the battery-powered applications. The uP1746 operates with 100% duty cycle and enters low dropout mode as the supply input approaches the output voltage. This maximizes the battery life.

Over Temperature Protection

The OTP is triggered and shuts down the uP1746 if the junction temperature is higher than 150°C. The OTP is a non-latch type protection. The uP1746 automatically initiates another soft start cycle if the junction temperature drops below 120°C.

Under Voltage Protection

The uP1746 under voltage protection is triggered if the FB voltage is lower than 0.25V, the Buck turns off both upper and lower MOSFET then always hiccups. When UVP is removed, the hiccup status will disappear.

Absolute Maximum Rating

(Note 1)

Supply Input Voltage, V_{IN} ---------- -0.3V to +6V
Other Pins ---------- -0.3V to 6V
Storage Temperature Range ---------- -65°C to +150°C
Junction Temperature ---------- 150°C
Lead Temperature (Soldering, 10 sec) ---------- 260°C
ESD Rating (Note 2)
HBM (Human Body Mode) ---------- 2kV
CDM (Charged Device Mode) ---------- 1kV

Thermal Information

Package Thermal Resistance (Note 3)

TSOT23 - 5L θ_{JA}	250°C/W
TSOT23 - 5L θ_{JC}	100°C/W
TSOT23 - 6L θ_{JA}	250°C/W
TSOT23 - 6L θ_{JC}	100°C/W
WDFN2x2 - 6L θ_{JA}	155°C/W
WDFN2x2 - 6L θ_{JC}	20°C/W
WQFN3x3 - 16L θ_{JA}	68°C/W
WQFN3x3 - 16L θ_{JC}	6°C/W

Power Dissipation, P_D @ T_A = 25°C

TSOT23 - 5L P_D	0.40W
TSOT23 - 6L P_D	0.40W
WDFN2x2 - 6L P_D	0.65W
WQFN3x3 - 16L P_D	1.47W

Recommended Operation Conditions

(Note 4)

Operating Junction Temperature Range ---------- -40°C to +125°C
Operating Ambient Temperature Range ---------- -40°C to +85°C
Supply Input Voltage, V_{CC} ---------- +2.6V to 5.5V

Note 1. Stresses listed as the above *Absolute Maximum Ratings* may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2. Devices are ESD sensitive. Handling precaution recommended.

Note 3. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

Note 4. The device is not guaranteed to function outside its operating conditions.

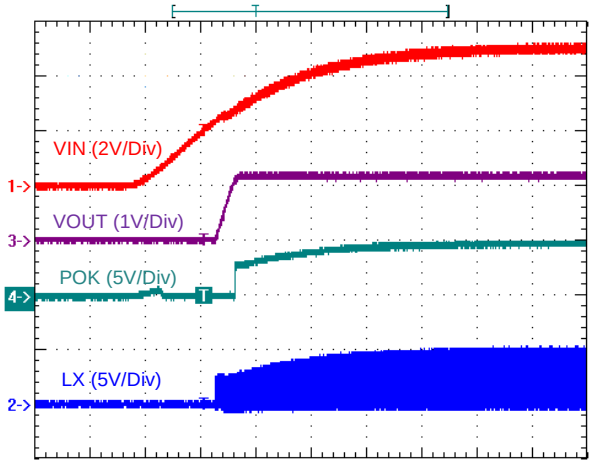
Electrical Characteristics

(V_{IN} = V_{EN} = 5V, T_A=25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Supply Input						
Supply Input Voltahe Range	V_{IN}		2.6	--	5.5	V
Under Voltage Lockout	V_{UVLO}	V_{IN} rising	--	2.3	--	V
		V_{IN} falling	--	0.2	--	
Quiescent Current	I_Q	V_{FB} = 0.65V, I_{OUT} = 0mA (no switching)	--	40	--	uA
Shutdown Current	I_{SHDN}	V_{EN} = 0V	--	0.01	0.1	uA
Reference						
Soft-Start Time	t_{SS}	V_{IN}=5V,V_{OUT}=3.3V,I_{OUT} =0mA	--	1	--	ms
Reference Voltage	V_{FB}		0.591	0.6	0.609	V
Output Voltage Line Regulation		V_{IN} = 2.6V to 5.5V	--	0.04	0.4	%/V
Output Voltage Load Regulation		I_{OUT} = 300mA to 2A	--	1	--	%/A
Oscillator						
Switching Frequency	f_{OSC}		--	1	--	MHz
Minimum On Time	T_{ON_MIN}		70	90	120	ns
Maximum Duty Cycle	D_{MAX}	V_{IN} = V_{OUT}; V_{FB} = 0.55V	100	--	--	%
Power Switches						
High-side Switch On-resistance	R_{P_FET}	I_{LX} = 200mA	--	100	--	mΩ
Low-side Switch On-resistance	R_{N_FET}	I_{LX} = 200mA	--	80	--	mΩ
Logic Input						
EN Logic High	V_{IH}	V_{IN} = 2.6V to 5.5V , Enable	1.5	--	--	V
EN Logic Low	V_{IL}	V_{IN} = 2.6V to 5.5V, Shutdown	--	--	0.4	V
Power OK Output						
POK Output High Threshold		Measured FB with Respect to VREF	--	90	--	%
POK Delay Time			--	100	--	us
POK Under Voltage Threshold			--	0.55	--	V
Protection						
FB Under Voltage Protection		FB Falling	--	0.25	--	V
Current limit Protection	I_{LM}		2.5	--	--	A
Thermal Shutdown Temperature	T_{SHDN}		--	150	--	°C
Thermal Shutdown Hysteresis	ΔT_{SHDN}		--	30	--	°C

Typical Operation Characteristics

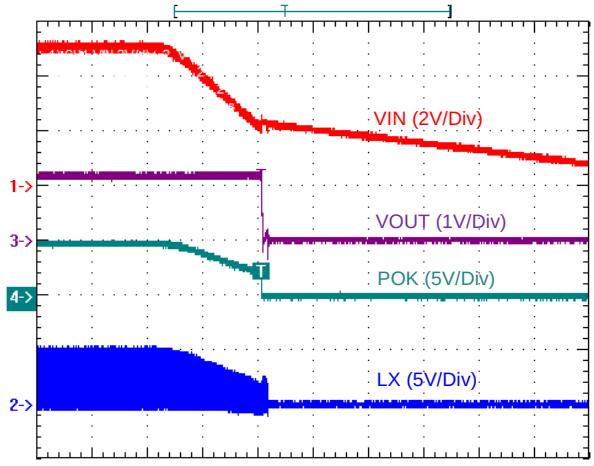
Power On from VIN



Time：2ms/Div

T_A = 25°C, V_{IN} = V_{EN} = 5V, V_{OUT} = 1.2V, I_{OUT} = 2A

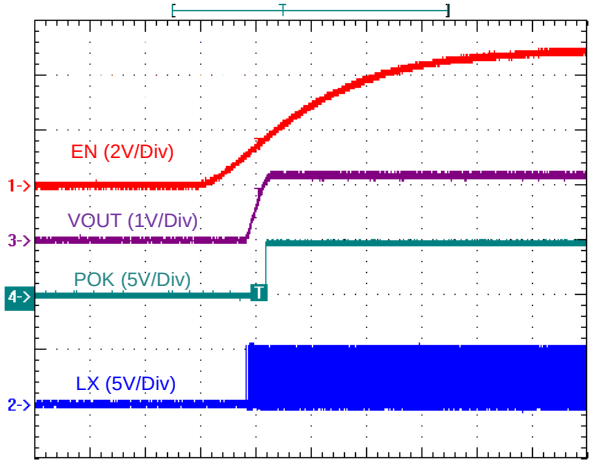
Power Off from VIN



Time：2ms/Div

T_A = 25°C, V_{IN} = V_{EN} = 5V, V_{OUT} = 1.2V, I_{OUT} = 2A

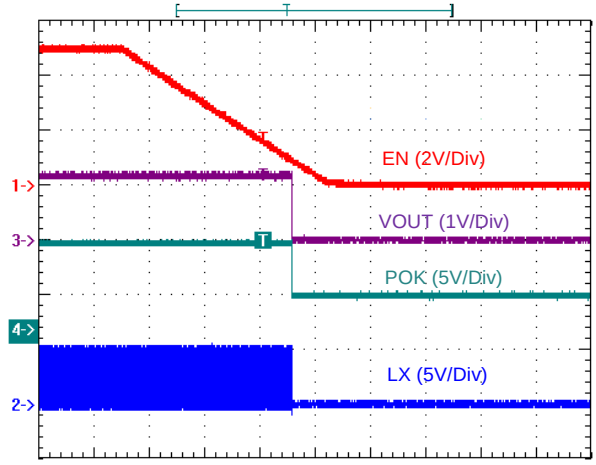
EN Turn On



Time：2ms/Div

T_A = 25°C, V_{IN} = 5V, V_{OUT} = 1.2V, I_{OUT} = 2A

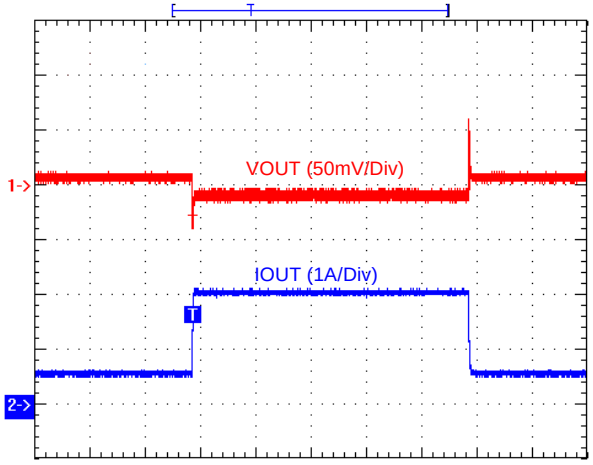
EN Turn Off



Time：10ms/Div

T_A = 25°C, V_{IN} = 5V, V_{OUT} = 1.2V, I_{OUT} = 2A

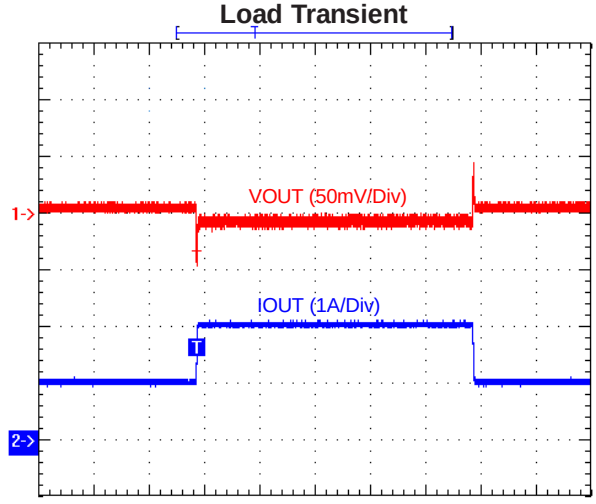
Load Transient



Time：1ms/Div

T_A = 25°C, V_{IN} = V_{EN} = 5V, V_{OUT} = 1.2V, I_{OUT} = 0.5A ~ 2A

Load Transient

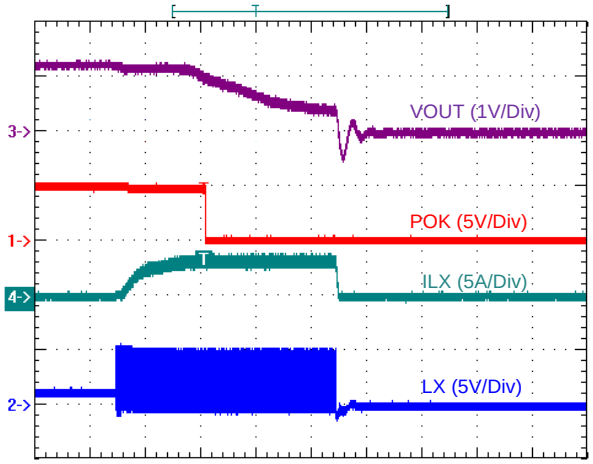


Time：1ms/Div

T_A = 25°C, V_{IN} = V_{EN} = 5V, V_{OUT} = 1.2V, I_{OUT} = 1A ~ 2A

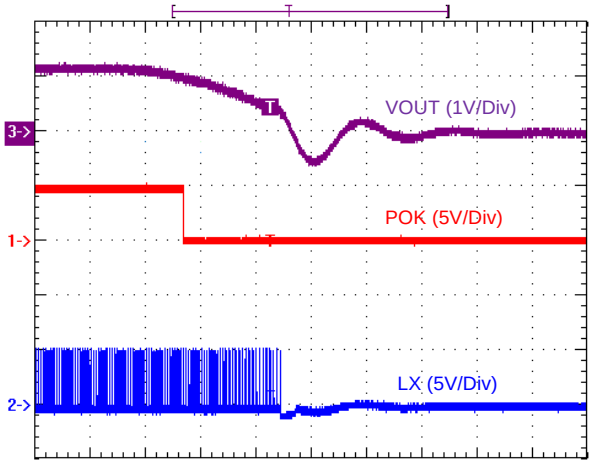
Typical Operation Characteristics

Over Current Protection



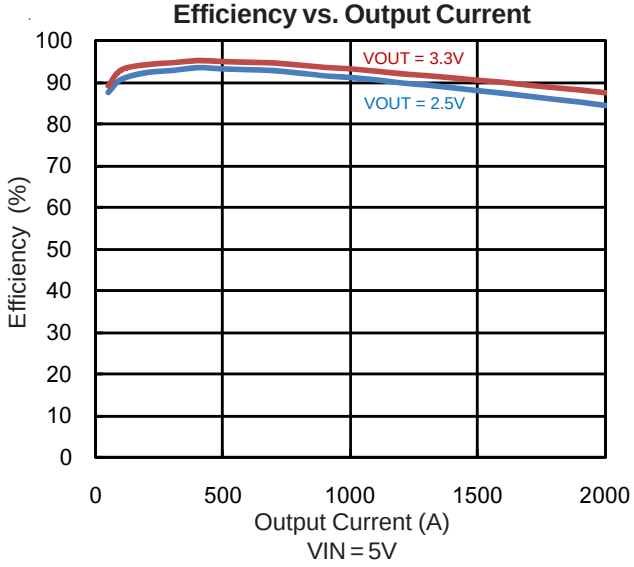
Time：100us/Div
T_A = 25°C, V_{IN} = V_{EN} = 5V, V_{OUT} = 1.2V

Under Voltage Protection



Time：20us/Div
T_A = 25°C, V_{IN} = V_{EN} = 5V, V_{OUT} = 1.2V

Efficiency vs. Output Current



Application Information

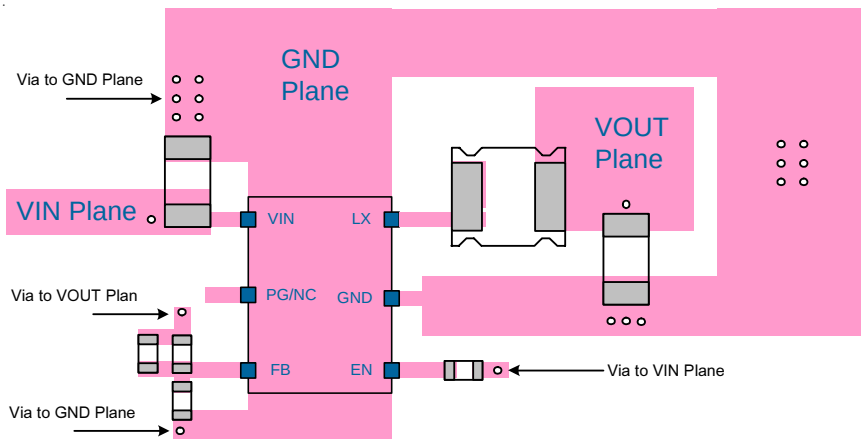
PCB Layout Considerations

The PCB layout is an important step to maintain the high performance of the uP1746. High switching frequencies and relatively large peak currents make the PCB layout is a very important part of all high frequency switching power supplies design. Both the high current and the fast switching nodes demand full attention to the PCB layout to save the robustness of the uP1746 through the PCB layout. Improper layout might show the symptoms of poor load or line regulation, radiate excessive noise at ground or input, output voltage shifts, stability issues, unsatisfying EMI behavior or worsened efficiency.

Certain points must be considered before starting a layout using uP1746 and the following recommendations need to be followed:

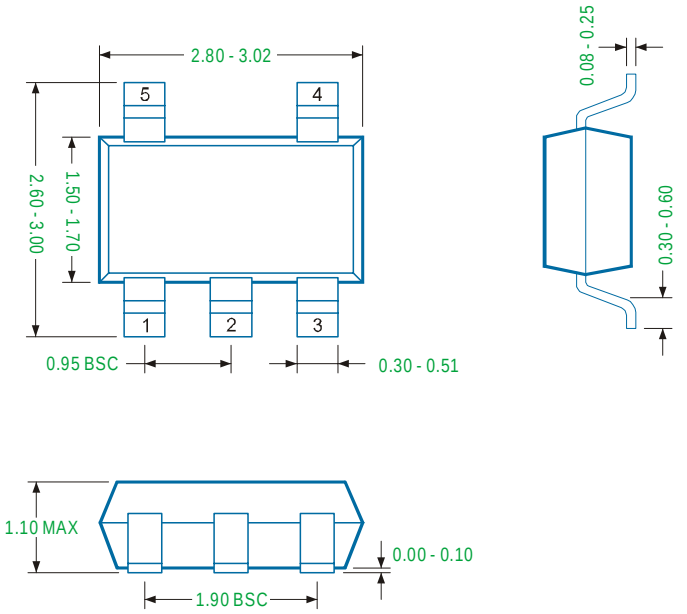
Layout Guidelines:

1. It is recommended to place all components as cloas as possible to the IC. Especially the VIN capacitor 10uF must be placed closest to the VIN pin of the device.
2. The FB resistors divider network should be placed close to the IC or FB pin and connected using Via directly to GND plane.
3. Keep the Sensitive signal (FB) away from the switching signal (LX).
4. Two or multi-layer PCB design is recommended.



Package Information

TSOT23 - 5L Package

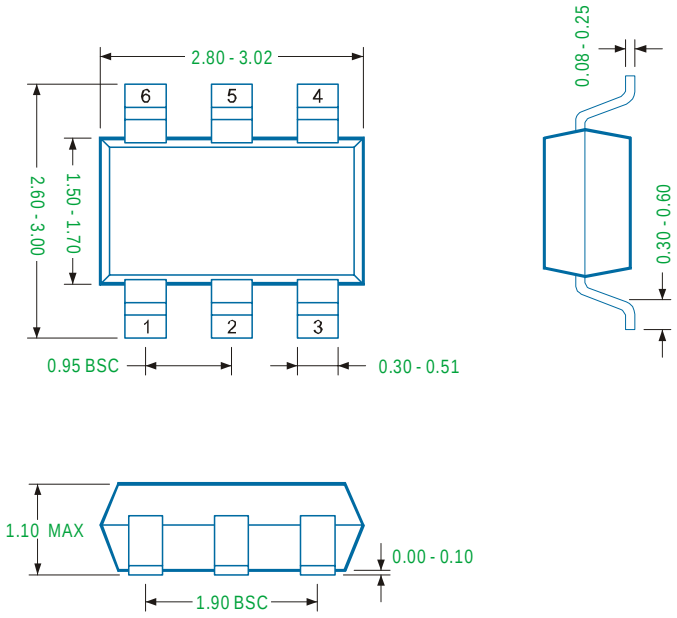


Note

1. Package Outline Unit Description:
   BSC: Basic. Represents theoretical exact dimension or dimension target
   MIN: Minimum dimension specified.
   MAX: Maximum dimension specified.
   REF: Reference. Represents dimension for reference use only. This value is not a device specification.
   TYP. Typical. Provided as a general value. This value is not a device specification.
2. Dimensions in Millimeters.
3. Drawing not to scale.
4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.

Package Information

TSOT23 - 6L Package

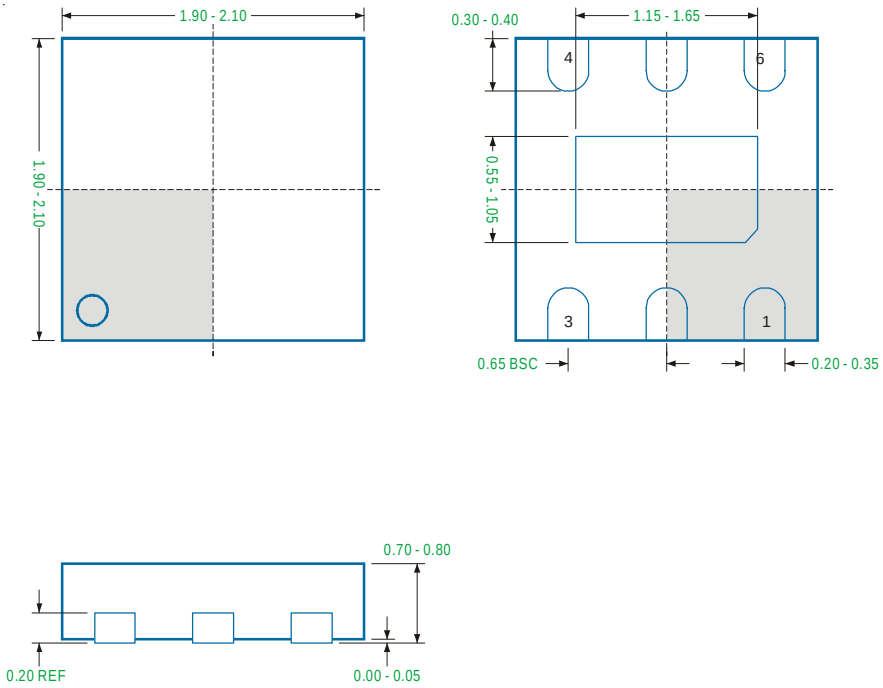


Note

1. Package Outline Unit Description:
   BSC: Basic. Represents theoretical exact dimension or dimension target
   MIN: Minimum dimension specified.
   MAX: Maximum dimension specified.
   REF: Reference. Represents dimension for reference use only. This value is not a device specification.
   TYP. Typical. Provided as a general value. This value is not a device specification.
2. Dimensions in Millimeters.
3. Drawing not to scale.
4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.

Package Information

WDFN2x2 - 6L Package

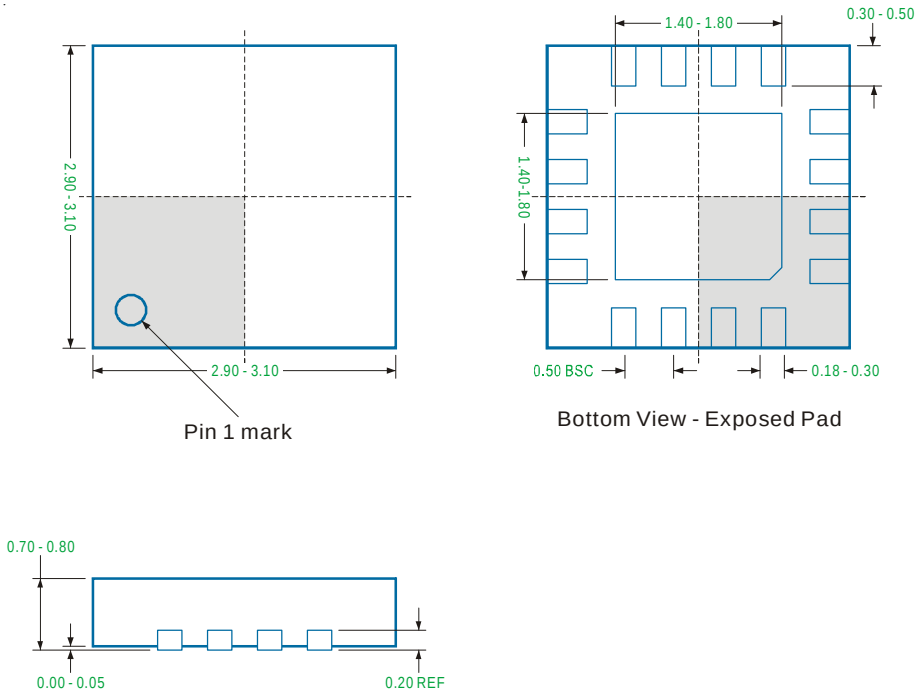


Note

1. Package Outline Unit Description:
   BSC: Basic. Represents theoretical exact dimension or dimension target
   MIN: Minimum dimension specified.
   MAX: Maximum dimension specified.
   REF: Reference. Represents dimension for reference use only. This value is not a device specification.
   TYP. Typical. Provided as a general value. This value is not a device specification.
2. Dimensions in Millimeters.
3. Drawing not to scale.
4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.

Package Information

WQFN3x3 - 16L Package



Note

1. Package Outline Unit Description:
   BSC: Basic. Represents theoretical exact dimension or dimension target
   MIN: Minimum dimension specified.
   MAX: Maximum dimension specified.
   REF: Reference. Represents dimension for reference use only. This value is not a device specification.
   TYP. Typical. Provided as a general value. This value is not a device specification.
2. Dimensions in Millimeters.
3. Drawing not to scale.
4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.

Important Notice

uPI and its subsidiaries reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

uPI products are sold subject to the taerms and conditions of sale supplied at the time of order acknowledgment. However, no responsibility is assumed by uPI or its subsidiaries for its use or application of any product or circuit; nor for any infringements of patents or other rights of third parties which may result from its use or application, including but not limited to any consequential or incidental damages. No uPI components are designed, intended or authorized for use in military, aerospace, automotive applications nor in systems for surgical implantation or life-sustaining. No license is granted by implication or otherwise under any patent or patent rights of uPI or its subsidiaries.

uPI Semiconductor Corp.
Headquarter
9F.,No.5, Taiyuan 1st St. Zhubei City,
Hsinchu Taiwan, R.O.C.
TEL : 886.3.560.1666 FAX : 886.3.560.1888

Sales Branch Office
12F-5, No. 408, Ruiguang Rd. Neihu District,
Taipei Taiwan, R.O.C.
TEL : 886.2.8751.2062 FAX : 886.2.8751.5064